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## Special issue: Original article

# The impact of executive functions on verb production in patients with Parkinson's disease

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## ABSTRACT

A growing number of studies suggest that language problems in Parkinson's disease (PD) are a result of executive dysfunction. To test this hypothesis we compared Dutch verb production in sentence context in a group of 28 PD patients with a control group consisting of 28 healthy participants matched for age, gender and education. All subjects were assessed on both verb production in sentence context as well as on cognitive functions relevant for sentence processing.

PD patients scored lower than healthy controls on the verb production ability-scale and showed a response pattern in which performance was worse (1) in base than in derived position; (2) in present than in past tense; (3) for intransitive than in transitive verbs. For the PD group the score on the verb production ability-scale correlated significantly with set-switching and working memory. These results provide support for previous research suggesting that executive dysfunctions underlie the performance of the PD patients on verb production. It is furthermore suggested that because of failing automaticity, PD patients rely more on the cortically represented executive functions. Unfortunately, due to the disturbed intimate relation between the basal ganglia and the frontal cortex, these executive functions are also dysfunctional.

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## 1. Introduction

Studies on impaired verb production have often focused on people with agrammatic Broca's aphasia. In this regard it has been shown that for agrammatic Dutch speakers finite verbs are more difficult to produce than non-finite verbs (Bastiaanse, 2008), and that the ability to produce finite verbs decreases when syntactic complexity increases (Bastiaanse

et al., 2002). For agrammatic English speakers, problems with the production of transitive verbs (Thompson et al., 1994, 1997; Thompson, 2003) as well as with the regularity of the past tense (Ullman et al., 1997) have been reported. However, the latter has not been replicated for German (Penke et al., 1999; Penke and Westermann, 2006) or for Dutch speakers (Bastiaanse, 2008; Penke and Westermann, 2006). Interestingly, several studies have also revealed specific verb

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processing deficits in Parkinson's disease (PD), a neurodegenerative disease mainly characterized by motor symptoms (i.e., tremor, rigidity and bradykinesia) and caused by significant dopaminergic striatal denervation (Wolters and Bosboom, 2007). For example, Grossman et al. (1994) showed impaired verb learning and Whiting et al. (2005) showed impaired thematic role mapping in patients with PD. In addition, Ullman et al. (1997) reported on the results of a sentence completion task, which required the participants to read aloud randomly ordered sentence pairs and to fill in a verb. Ullman et al. (1997) reported a correlation between right-side hypokinesia and the impaired production of rule-generated (regular) past tense forms in PD. The authors concluded that PD leads to the suppression of both motor activity and grammatical rule application. In essence, Ullman et al. (1997) and Ullman (2001) proposed that the frontal-basal ganglia system constitutes the procedural memory system that regulates grammar and that the mental lexicon depends on declarative memory, embedded in the temporal lobe. In the following years, the vast majority of studies on verb production in PD focused on testing the Declarative-Procedural hypothesis of Ullman et al. (1997), but the PD data of the Ullman-study could not be replicated (Almor et al., 2002; Longworth et al., 2003, 2005; Penke et al., 2005; Terzi et al., 2005). In their replication study, Longworth et al. (2005) found a tendency in English speaking PD patients to perseverate on the cue (i.e., verb stem) rather than to produce a past tense as requested. This finding is in line with the conclusions of Robles et al. (2005) for perseveration on the previous picture in a naming task during direct stimulation of the dominant head of the caudate nucleus. Verb retrieval abilities in PD were specifically tested by Piatt et al. (1999a, 1999b) using an action fluency task (for more details see the methods section of this article). Piatt et al. (1999a, 1999b) concluded that action fluency was particularly sensitive to the fronto-striatal pathophysiology of PD with dementia. According to these authors action fluency reflects the underlying integrity of frontal lobe circuitry, and could therefore indicate deficits in executive functioning. Péran et al. (2003) developed a French word-generation task that required a semantic and grammar driven selection of single words over a limited time period. Compared to healthy control subjects, PD patients showed a higher rate of grammatical errors in the noun → verb-generation task than in the verb → noun-generation task. Péran et al. (2003) hypothesized that this discrepancy might be due to the combined effect of impaired set-switching and a grammatical impairment in verb production. The authors suggested that in the verb → noun task, the impact of impaired switching is compensated by the easier noun production, whereas in the noun → verb task both switching and production of the verb were dysfunctional. Evidence for a selective verb production deficit in PD was previously reported by Bertella et al. (2002). More recently, Boulenger et al. (2008) corroborated this finding of a selective deficit for the processing of action verbs in PD patients off their dopaminergic medication. More in particular these researchers hypothesized that the access to action verbs partly relies on the motor system. According to their view, the nigrostriatal system, that is affected in PD, seems to modulate action word processing in the motor areas.

The PD studies reviewed above evidence that dysfunctional frontal-striatal circuits influence verb processing and reveal that basal ganglia, are critical in verb processing. Moreover, several other studies in PD provide us with evidence for the involvement of the fronto-striatal circuits in other aspects of language processing, than just verb processing. Illes et al. (1988) were the first to report grammatical deficits in the spontaneous speech of PD patients. It was found that PD patients limit their speech to short and syntactically simple structures (Illes, 1989; Illes et al., 1988). In a study of sentence comprehension, Lieberman et al. (1992) reported that speech motor deficits accompanied the grammatical and cognitive deficits in PD patients. The common neurological basis for these deficits was suggested to be the disruption of the circuits between subcortical structures and prefrontal cortex. Following this statement, Lieberman et al. (1992) and Lieberman (2000, 2006) claimed that as language is neurologically intertwined with cognition and motor control it can't be modular in nature.

Several independent studies consistently found reduced comprehension of syntactically complex sentences as well as long sentences (e.g., Grossman et al., 1991, 1992, 1993; Hochstadt et al., 2006; Lieberman et al., 1990, 1992; Natsopoulos et al., 1991, 1993) and deficits in lexical ambiguity resolution in PD (Copland et al., 2000, 2001). Another consequence of the dysfunctional fronto-striatal circuits such as in PD is a delay in lexical activation during semantic priming studies (Angwin et al., 2004; Arnott et al., 2001). Neuroimaging studies in healthy subjects lend additional evidence to the finding that fronto-striatal circuits contribute to language processing. In an attempt to separate syntactic and semantic aspects of sentence processing with functional Magnetic Resonance Imaging (fMRI), Ni et al. (2000) found activity in the head of the caudate nucleus at about 10 sec after a syntactic anomaly. Similar findings were obtained in a study using  $H_2^{15}O$  Positron Emission Tomography (PET) by Moro et al. (2001) who reported a selective activation of the left caudate nucleus during a syntactic anomaly condition. Using fMRI, Grossman et al. (2003) showed striatal activation in healthy senior volunteers during the comprehension of sentences with a long noun-gap linkage [e.g., Object-relative, long linkage: (The messy boy)<sub>i</sub> who Janet the very popular hairdresser grabbed <sub>t<sub>i</sub></sub> was extremely hairy] compared to sentences with a short linkage [e.g., Object-relative, short linkage: (The flower girl)<sub>i</sub> who Andy punched <sub>t<sub>i</sub></sub> in the arm was five years old]. Stowe et al. (2004) reported activation in the right basal ganglia of healthy subjects during a syntactic disambiguation task.

What is of great importance to the present study is that dysfunctional fronto-striatal circuits affect more cognitive functions than just the discussed linguistic functions. Neuropsychological assessment has found that, visuospatial, memory, and executive functions are impaired in nondemented PD patients (Dubois and Pillon, 1997; Pillon et al., 2003). It has been proposed (Dagher et al., 2001; Owen et al., 1998) that the executive deficits may be caused by disruption of basal ganglia outflow resulting in frontal dysfunction in the different loops connecting the prefrontal cortex, basal ganglia, and thalamus (Alexander et al., 1986). A [18F]fluorodopa PET study (Bruck et al., 2001) and a  $^{11}C$ -S-Nomifensine

PET study (Marié et al., 1999) showed a correlation between the degree of impairment on executive tasks and the dopaminergic hypofunction in the caudate nucleus, indicating that the disturbances in the dopaminergic system are involved in the cognitive impairments in PD. The results of these two PET studies also pointed to distinct and complex relationships between striatal dopamine and specific neuropsychological tasks. Since language is a higher cognitive function and involves frontally represented executive functioning, the executive dysfunctions in PD patients might influence their language processing. In other words, fronto-striatal circuits are implicated in various cognitive functions that may subserve language.

Consequently a crucial debate has arisen on the role of the basal ganglia in language processing.

As Marsden and Obeso (1994) pointed out, damage to the basal ganglia results in both motor and cognitive inflexibility. Cognitive inflexibility or set-switching impairments in human behavior implies that an inappropriate automatic response cannot be easily aborted (inhibited) and concomitant planning of a new more appropriate sequence is disturbed due to lack of appropriate activation (Marsden and Obeso, 1994). Neuroimaging studies in healthy control (HC) subjects show fronto-striatal activity when receiving a signal that a switch is needed (Monchi et al., 2001). In PD set-switching impairments (e.g., Cools et al., 2001) and a lack of activation in the fronto-striatal circuit during a set-switching paradigm have been reported (Monchi et al., 2004).

As noted earlier in this Introduction, Lieberman et al. (1992) demonstrated that speech production, sentence comprehension and cognitive deficits co-occurred in PD and are all caused by a deterioration of the cortical-striatal-cortical circuits. Following this finding, Lieberman (2006) focused on the activating or inhibiting “local operations” performed by the basal ganglia within the cortical-striatal-cortical circuits. Lieberman (2006, 2007) defined the basal ganglia as a “sequencing engine” that can reiterate motor patterns generators as well as cognitive pattern generators. Applied to syntax, the basal ganglia can thus generate an infinite number of possible sentences by combining a finite set of words using a finite set of rules (Lieberman, 2006, 2007). Within syntactic processing, the basal ganglia switch then from one linguistic subprocess to the next at the right moment in time.

In what follows a short overview of verb formation in Dutch is given.

Although Dutch and English are both Germanic languages, there are fundamental grammatical differences, which mainly concern word order. English is known as a Subject – Verb – Object language, meaning that the verb, whether it is finite (i.e., inflected for Tense and Agreement with the subject) or non-finite always precedes the object. In English nothing can be put between the verb and the object. In contrast Dutch is a Subject – Object – Verb language, with a grammatical rule, linguistically known as Verb Second that postulates that in the main clause the finite verb should be in second position. This implies that non-finite verbs (infinitives and participles) and finite verbs in subordinate clauses always follow the object. In (1)–(3), some examples of Dutch sentences are given.

- (1) finite verb in a subordinate clause; verb in base position  
de jongen die een boek leest  
the boy who a book reads  
(the boy who is reading a book)
- (2) finite verb in a main clause; verb in derived position  
de jongen leest een boek  
the boy reads a book  
(the boy is reading a book)
- (3) auxiliary + non-finite verb in a main clause; finite auxiliary in derived position and non-finite verb in base position  
de jongen will een boek lezen  
the boy wants to a book read  
(the boy wants to read a book)

In short: finite verbs in subordinate clauses and non-finite verbs in main clauses are in base position and finite verbs and finite auxiliaries in main clauses are in derived position.

With respect to past tense, Dutch is similar to English: there are regular and irregular verbs. Below examples are given (see examples 4–6). In Dutch regular or ‘weak’ past tense and participles are rule-governed (see example 4 and 5). The finite past form is formed by adding [-də] or [-tə] to the stem of the verb, dependent on the final phoneme of the stem. In Dutch the participle is different from the past tense: prefix [χə-] + verb stem + ending [-t] (see example 4 and 5). The stems of irregular or ‘strong’ verbs usually undergo a vowel change in the past tense and the participle is formed by prefix [χə-] + verb stem (vowel change) + ending [-ən] (see example 6).

	Infinitive	Past	Participle	Translation
(4)	wurg + [-ən]	wurg + [-də]	[χə-] + wurg + [t]	‘strangle’
(5)	vis(s) + [-ən]	vis + [-tə]	[χə-] + vis + [t]	‘fish’
(6)	blink + [-ən]	blonk	[χə-] + blonk + [-ən]	‘shine’

So far the production of verbs in sentence context has not been studied. By manipulating the grammatical features of the test sentences, verb retrieval and sentence integration processes can be tested simultaneously. Compared to verb retrieval in isolation, testing verbs in sentence context is closer to the natural language processes since we usually speak in sentences and not in isolated single words. Therefore the present experiment used sentence materials traditionally employed in aphasia studies to probe verb production in sentence context. Subsequently the verb production performances of the PD patients were correlated to their scores on executive function tasks.

In summary, there is general agreement that PD may result in (morpho)syntactic deficits. The relation to other cognitive deficits is, as yet, unclear, especially with respect to the role of the verb in the sentence. The main goal of the present study is, therefore, to explore the relation between possible verb-in-sentence-context deficits and executive functions that are relevant for sentence processing: attention, working memory, set-switching, inhibition, fluency and abstract sequencing abilities. The study compared a group of Dutch speaking PD patients with a group healthy controls matched for age, gender and education. In addition, correlating PD patients’ clinical features with verb production in sentence context will give us more information on the effects of basal ganglia dysfunction and dopaminergic therapy.

## 2. Methods

### 2.1. Subjects

Twenty-eight PD patients participated in the study; all were diagnosed according to the criteria of the UK Parkinson's Disease Society Brain Bank. All patients were assessed with the Unified Parkinson's Disease Rating Scale, part III (UPDRS; [Fahn and Elton, 1987](#)). One of the authors (K.L.L.), who is a neurologist specialized in movement disorders, used the UPDRS score to estimate the [Hoehn and Yahr \(1967\)](#) stage averaged over the best and worst condition per patient. Furthermore, to test Ullman's claim that the left basal ganglia are involved in rule processing, right lateralized hypokinesia was measured using the four hand and foot movement subtests of the UPDRS as described in [Ullman et al. \(1997\)](#) and [Longworth et al. \(2005\)](#). Additionally, left lateralized hypokinesia was also measured, using the same procedure as with right lateralized hypokinesia. All patients were on antiparkinsonian medication during assessment. A levodopa equivalent daily dose score (LEDD-score) was calculated according to the following formula: regular levodopa dose  $\times$  1 + slow release levodopa  $\times$  .75 + bromocriptine  $\times$  10 + apomorphine  $\times$  10 + ropinirole  $\times$  20 + pergolide  $\times$  100 + pramipexole  $\times$  100 + [regular levodopa dose + (slow release levodopa  $\times$  .75)]  $\times$  .2 if taking entacapone ([Esselink et al., 2004](#)) (see [Table 1A](#)).

PD patients were compared to twenty-eight healthy volunteers recruited from the Groningen community, who were aged and education matched with the patients (see [Table 1B](#)). Both groups were also matched for gender and consisted of sixteen males and twelve females. Exclusion criteria for both groups were dementia (Mini-Mental State Examination-score (MMSE)  $<$  25) and depression (Montgomery-Asberg Depression Rating Scale score (MADRS)  $\geq$  18). Patients and control subjects were all native speakers of Dutch, who reported no premorbid language difficulties.

The Medical Ethical Committee of the University Medical Center Groningen (UMCG) approved this study. Prior to

**Table 1A – Demographic and clinical data of the PD group.**

	Mean ( $\pm$ SD)	Range
Gender (male:female)	16:12	–
Handedness (right:left)	27:1	–
Age in years	61.39 (8.8)	45–78
Education in years	13.21 (3.9)	8–24
MMSE	28.11 (1.13)	25–29
MADRS	6 (4)	0–17
Duration of disease in years	6.04 (4.55)	1–19
UPDRS part III	15.68 (5.35)	5–30
Right-side hypokinesia	3.84 (2.43)	0–10
Left-side hypokinesia	3.12 (2.28)	0–8
Hoehn & Yahr staging	1.79 (.523)	1–2.75
LEDD-score	786.94 (472.45)	150–1969

UPDRS and right and left-side hypokinesia data available for twenty-five patients (data missing from three patients); Hoehn & Yahr scale available for twenty-seven patients (from one patient data missing), LEDD-score available for twenty-seven patients (from one patient data missing).

**Table 1B – Demographic and clinical data of the healthy control group.**

	Mean ( $\pm$ SD)	Range
Gender (male:female)	16:12	–
Handedness (right:left)	24:4	–
Age in years	62.93 (9.04)	46–82
Education in years	13.57 (3.25)	8–19
MMSE	27.64 (1.22)	25–29
MADRS	3.32 (2.83)	0–11

participation the subjects gave their written informed consent according to the Declaration of Helsinki.

### 2.2. Experimental tasks and procedures

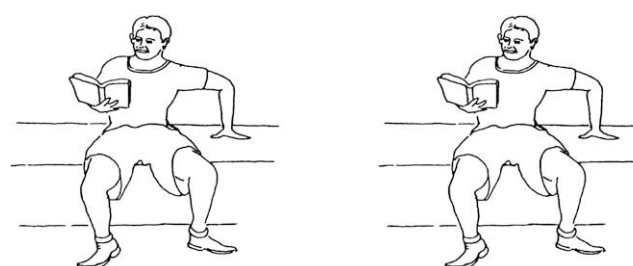
#### 2.2.1. Verb production task

Subjects performed an un-timed verb-in-sentence-context task to assess verb production. Ten regular and ten irregular verbs were selected and controlled for lemma frequency and transitivity according to the Dutch Celex database ([Baayen et al., 1993](#)). The complete list of Dutch verbs used in this study and their English translation is given in [Appendix A](#). The test sentences were developed by manipulating three linguistic variables:

1. Finiteness: production of 20 infinitives versus 80 finite verbs.
2. Position of the verb: inflection of 40 finite verbs in sentence final position (basic word order) versus 40 finite verbs in verb second position (derived word order).
3. Tense: inflection of 40 verbs in the present tense versus 40 verbs in the past tense. The past tense sentences were created by adding a temporal adjunct (e.g., “yesterday”) to the present tense sentence.

An accompanying picture depicting the targeted action in the incomplete sentence was designed. To illustrate the sentence materials, two examples of test items assessing the position of the verb are given in [Fig. 1](#).

The following procedure was used: subjects were seated in front of a computer screen and were presented with a picture. A sentence was printed underneath the picture. The subjects were then instructed to read the sentence aloud and to



Dit is de jongen die een boek... (leest). This is the boy who a book... (reads). De jongen... (leest) een boek. The boy... (reads) a book.

**Fig. 1 – In the item on the left, the verb needs to be inflected in base position and in the item on the right the verb needs to be inflected in the derived position.**



produce the missing verb. They were explicitly told to inflect the verb in the past tense only in the presence of a past tense adverbial time phrase (e.g., ‘yesterday’) and to inflect the verb in the present tense if an adverbial of time phrase was missing. In order to familiarize the subjects with the task, five practice items were given and feedback was provided (one practice item for each condition).

To avoid order effects two different lists of pseudo-randomly ordered stimuli were developed. Fifty percent of the healthy control subjects completed version A of the verb production task and 50% completed version B. In the PD group, 57% completed version A and 43% completed version B.

The responses of the subjects were digitally recorded and transcribed by the experimenter. The recordings were only used when the experimenter was uncertain of the intelligibility of the response of the subject. The accuracy of the verbs was scored by two independent judges (authors K.S.F.C. and R.B.) and for all items consensus was reached. A verb was considered to be correct if the target verb or a semantically plausible alternative was produced with the correct inflection. A qualitative analysis of errors was conducted. Errors were classified in different types for both the infinitives and the finite verbs separately. Errors made by patients in the production of the finite verbs were subdivided by condition, resulting in separate schemes of errors for tense, position and regularity. For each condition, errors were classified post hoc and included the following categories: (a) lexical semantic errors (i.e., production of irrelevant paraphrasias, circumlocutions or neologisms), (b) finiteness errors (i.e., production of infinitives or present participles), (c) regularization errors, and (d) tense errors (i.e., inappropriate present or past tense or multiple errors). Multiple errors concern two aspects of the verb inflection: first, instead of the required present tense, a simple past was produced and the second aspect concerns the produced verb form which was either regularized (e.g., *hangde* instead of the correct *hing* ‘hang’) or contained a phonological distortion of the vowel change (e.g., *hong* instead of the correct *hing* ‘hang’).

## 2.2.2. Neuropsychological assessment

The following cognitive functions were assessed by using standard neuropsychological tests: attention, working memory, cognitive set-switching, inhibitory control, fluency and abstract sequencing.

**2.2.2.1. Attention.** Three different subtests of the Testbatterie zur Aufmerksamkeitsprüfung (TAP, Zimmermann and Fimm, 2000) were administered to assess the following attentional functions: sustained visual attention, sustained auditory attention and divided attention. The sustained visual attention task had a duration of 10 min during which participants had to push a button when recognizing irregularities in a normally regular movement pattern of an object on a computer screen. The number of times subjects did not recognize an irregularity was counted. The sustained auditory attention task also had a duration of 10 min and consisted of a regular sequence of high and low tones. The subject had to detect irregularities in the sequence and the number of undetected irregularities was counted. Divided attention was assessed during 4 min by using the dual task of the TAP. This dual task has two subtasks which had to be performed

simultaneously. The first task consisted of crosses appearing in a random configuration in a  $4 \times 4$  matrix. The subject had to detect whether the crosses formed the corners of a square. During the second subtask participants had to detect irregularities in a sequence of tones. For each subtask, the number of omissions was recorded.

**2.2.2.2. Working memory.** Working memory was assessed with the digit span forward and backward of the Wechsler Adult Intelligence Scale (WAIS, [Stinissen et al., 1970](#)). The total number of strings of digits repeated correctly by the participant in the forward and backward condition was recorded.

**2.2.2.3. Cognitive set-switching.** The Trail Making Test parts A and B (TMT A and B, [Reitan, 1992](#)) and the Odd Man Out test (OMO test, [Flowers and Robertson, 1985](#)) were administered to assess cognitive set-switching. The target measure of the Trail Making was the performance on part B corrected for psychomotor speed (by dividing it by the performance on part A), the B/A index. The total error score was the target measure of the OMO test.

**2.2.2.4. Inhibitory control.** The time score on the Stroop-Color-Word Card of the Stroop-Color-Word Test ([Stroop, 1935](#)) divided by the time needed on the Stroop-Color Card was used to assess response inhibition.

**2.2.2.5. Verbal fluency.** Verbal fluency tests are thought to require intact verbal memory (participants need intact storage and retrieval of semantic information), executive functioning (like self initiation and switching) and psychomotor speed ([Bouma et al., 1998](#); [Troyer, 2000](#); [Mayr, 2002](#)).

Three different verbal fluency subtests were administered:

- Letter category task

The phonemic fluency test required naming words beginning with the letters, D, A and T, for 60 sec each, which are comparable in frequency to F, A and S as initial letter for English. The total number of correct words for each letter was counted and an average score was calculated.

- Semantic category task

The semantic fluency tasks of the Groninger Intelligence Test, (GIT vv, [Kooreman and Luteijn, 1987](#)) required the subjects to generate as many animals and professions, in 60 sec. The total number of correct words for each category was counted and an average score was calculated.

- Action fluency task

We assessed the Action Fluency Test as described by [Piatt et al. \(1999a, 1999b, 2004\)](#). This task required subjects to orally generate as many actions (“things that people do”) as they could in a 60 sec period. We recorded the total number of unique named verbs.

**2.2.2.6. Abstract structure processing.** Finally, abstract structure processing was evaluated with a protocol based on [Lelekov et al. \(2000\)](#). The aim of the task was to test the ability to learn letter-sequences with a simple (e.g., A–B–C–A–B–C) and complex abstract structure (e.g., A–B–C–B–A–C) in order to be

able to judge whether a given letter-sequence followed the just learned structure or not. The procedure of assessment of learning either structure was as follows: during an initial familiarization and training period the subject had to study a list of letter-sequences with an identical abstract structure. Subsequently subjects had to determine whether twenty not-trained sequences were or were not corresponding to the abstract structure of the training phase. For example: “Does Z-W-K-W-Z-K follow the (complex abstract) structure?” The answer is: “Yes”. The simple and complex structures were administered in a separate session. Half the subjects started with the simple structure and half with the complex structure. All the materials and instructions were presented on paper and the subjects had to mark the sequences as correct or incorrect. The assessment was terminated when subjects showed a persistent inability to perform the task. Uncompleted testing was scored at chance level (i.e., score of 10/20).

### 2.3. Statistical analyses

#### 2.3.1. Verb production ability-scale: construction

The Mokken-model (Mokken, 1971) was used to analyze the performance of all subjects on the verb production task.

The Mokken-model is based on the principles of the Item Response Theory (IRT), frequently used in psychometry, and specifically developed for measuring latent traits like verb production ability (Molenaar and Sijtsma, 2000). The underlying idea is that one can measure the latent trait by a scale consisting of items (e.g., produced verbs in sentence context) based on responses of persons (patients and healthy controls) on the items, assuming a certain mathematical relationship between the responses on the items and the latent trait. In our study, the response of each person on each produced verb is ‘correct’ or ‘incorrect’ (the outcome of the verb production task). The number of correct responses of a person is an estimate for its location on the scale. A larger number means a greater ability of a person. The number of persons giving a correct response on the item is an estimate for the item location. A smaller number means a more difficult item. In this way, a measurement scale is estimated with persons and items on the scale, indicating the ability of each person, and the difficulty of each item. This makes it possible to compare persons with each other, but also items (production verbs) with each other.

Each of the 100 produced verbs in sentence context was scored correct or incorrect and was treated as an ‘item’. For these analyses the following steps were taken:

1. Data of PD patients and healthy control subjects on the verb production task were combined. Items produced correctly by all participants were removed from the data-set.
2. Mokken-scale-analysis (Mokken, 1971) was used to determine which items were scalable. The Mokken-scale analyses were performed with MSP version 5.0 for Windows (Molenaar and Sijtsma, 2000).
3. The default options of the program were used. Problematic items were removed. Only 45 items with a scalability value of  $H > .15$  were included in the scale. This scale can be regarded as a verb production ability-scale.

4. The position of the items in the verb production ability-scale was the rank order ordering the 45 items of the scale from difficult to easy.

5. Finally, a verb production ability-scale score for all participants was calculated, i.e., the sum of the number of items which were part of this scale and that were answered correctly.

#### 2.3.2. Verb production ability-scale: analyses

In further analyses, the relation between the linguistic characteristics of the items and the difficulty of the items of the verb production ability-scale was assessed. This was based on the obtained Mokken-scale. Differences between (1) verbs in derived and in base position, (2) transitive and intransitive verbs and (3) regular and irregular verbs were analyzed with the t-test. A one-way ANOVA was used to determine, whether verbs in the present tense, verbs in the past tense and infinitives differed with respect to the difficulty of the items.

#### 2.3.3. Comparisons between groups

The performance of the PD patients and healthy controls was compared on all cognitive tests and on the ability-scale using the Mann–Whitney U-test. Since the TMT and the OMO test were both used to assess set-switching, the scores on these tests were combined using z-scores. Also, the scores on the three different fluency tasks were combined into the average fluency score.

#### 2.3.4. Error analyses

Because the control group hardly made any errors, the descriptive error analyses were restricted to the PD group. Completing the sentence with an infinitive elicited only a small number of errors, therefore the infinitive was not taken into account in further error descriptions. In order to define an error type as relevant, a cut-off for errors was calculated according to the following formula:  $14(\text{half of PD group}) \times \% \text{ of one error}$ . Error types scoring below the calculated cut-off score were designated as being ‘not relevant’ and were not further reported.

#### 2.3.5. Correlation analyses

The test scores of the PD patients were not normally distributed and therefore non-parametric (Spearman) correlations between the score on the ability-scale and the scores on the cognitive tests as well as their relevant clinical features were computed.

## 3. Results

### 3.1. Verb production ability-scale

Twenty-seven of the 100 items were answered correctly by all the participants and were removed from the data-set. Using Mokken-scale-analysis (Mokken, 1971), 28 items of the 73 remaining items did not meet the requirements of the Mokken-model and were omitted from the data-set as well. The characteristics of the removed items did not differ from the items of the scale. The remaining set of 45 items formed a verb

production ability-scale with  $H = .39$  and reliability of .95 (see for the verbs in sentence context Table B1 in Appendix B).

Studying the relationship of the linguistic variables and the difficulty of the 45 items on the verb production ability-scale reveals that finite verbs in derived position in the main clause were significantly easier than in base position in the subordinate clause ( $p < .01$ ). Transitive verbs were significantly easier to produce than intransitive verbs ( $p < .05$ ). There was no evidence for a difference between regular and irregular verbs ( $p > .10$ ). Also, finite verbs in past and present tense and infinitives were significantly different ( $p < .0001$ ). Pairwise comparisons revealed that the production of the present tense was significantly more difficult than the past tense ( $p < .0001$ ) and the infinitive ( $p < .0001$ ). No difference was found between production of the past tense and the infinitive.

### 3.2. Comparisons between groups

PD patients scored significantly lower [mean score = 39.32 ( $SD = 7.15$ )] than healthy controls [mean score = 44.21 ( $SD = 1.57$ )] on the verb production ability-scale ( $p < .0001$ ).

PD patients scored significantly lower on set-switching ( $p < .05$ ) and on sustained visual attention ( $p < .005$ ). For all other cognitive functions no significant differences were found between PD patients and healthy controls. However, a trend toward a difference between the groups was evident for the action fluency task ( $p < .10$ ). Table 2 shows the scores on the cognitive tests of both groups and a comparison between the groups.

### 3.3. Error analyses

Table 3 summarizes PD patients' error percentages above the cut-off score for production of past tense when a finite verb in the present tense is required (31 items of the 45 items in the ability-scale).

The PD group produced in 13.59% of the 31 present tense items a verb in the past tense instead of the present tense. This inappropriate production of the past tense was produced more than twice in the base position (18.75% of the total of analyzable items in base position) compared to the derived position (8.10% of the total of analyzable items in derived position).

Furthermore, 12.38% of the regular inflected verbs and 14.73% of the irregular inflected verbs were inappropriately inflected in the past tense when a present tense was required.

The error analyses revealed that PD patients overused the past tense. Additional analyses were performed to evaluate in more detail the influence of the preceding item on the production of the present tense items. Switch pairs and non-switch pairs were distinguished. In a switch pair of items two successive items had different cues as to which condition to use and therefore a set switch in time frame was necessary. More in particular, a switch pair involved as a first item a past tense item, cued by an adverbial time phrase [item (1a) in example below] and as a second item a present tense item without an adverbial time phrase [item (1b) in example below]. In the following an example of a switch pair is given:

- (1a) De vrouw wrong daarnet de dweil  
(The woman just wrung the floor cloth)  
(1b) Dit is de man die in de kerk knielt  
(This is the man who is kneeling in the church)

Conversely, in a non-switch pair of items, the two items of the pair had the same cues and no switch was needed [i.e., both the first (2a) and second (2b) item of the pair were in the present tense condition]. Also an example of a non-switch pair is given:

- (2a) Dit is de hond die de kat bijt  
(This is the dog that is biting the cat)  
(2b) De vrouw zeeft het meel  
(The woman sifts the flower)

As a group the PD patients produced 20% tense errors in the switch pairs compared to 17% in the non-switch pairs.

### 3.4. Correlation analyses

Associations were calculated between the scores of PD patients on the verb production ability-scale, the various cognitive functions and the clinical features. Table 4 lists the correlations between the ability-scale and cognitive functions in PD and healthy controls. In the PD group the score on the ability-scale correlated negatively with set-switching [ $r_s = -.61$ ,  $p < .005$ ].

**Table 2 – Performance on the cognitive measures within groups and comparisons between groups.**

	PD, n	PD performance, mean (SD)	HC, n	HC performance, mean (SD)	U	p
Sustained visual attention	27	1.3 (2.33)	25	.08 (.28)	207.5	.002*
Sustained auditory attention	26	.58 (1.03)	24	.38 (.77)	281	.455
Divided attention	26	1.96 (1.89)	25	1.4 (1.23)	277.5	.357
Digit span forward	28	7.5 (2.3)	28	7.54 (2.3)	381.5	.861
Digit span backward	28	6.61 (2.04)	28	7.36 (2.47)	343.5	.422
Set-switching (TMT A&B; OMO test)	27	.27 (.89)	28	-.27 (.7)	225	.01*
Stroop test	27	1.69 (.37)	28	1.57 (.28)	320	.329
Letter fluency (average)	27	13.63 (5.47)	28	15.32 (4.53)	323	.353
Semantic fluency (average)	28	20.77 (4.95)	28	21.23 (4.21)	348	.47
Action fluency	27	15.59 (6.74)	28	19.32 (5.46)	266.5	.06
Sequencing simple (max = 20)	28	18.79 (2.67)	27	19.81 (.4)	300.5	.095
Sequencing complex (max = 20)	28	17.61 (3.58)	27	19.04 (1.19)	334	.434

HC = healthy control; \* $p < .05$ .



**Table 3 – PD patients' error percentages above the cut-off score for production of past tense when a present tense is required.**

Target	Number of analyzable items	Cut-off score in %	Errors in %
Present tense	31	1.61	13.59
• Base position	16	3.13	18.75
• Derived position	15	3.33	8.10
• Regular	15	3.33	12.38
• Irregular	16	3.13	14.73

This means that as the z-score for switching increased with worse performance on the TMT and OMO test, the score on the verb production ability-scale decreased. The ability-scale score also correlated positively with the digit span backward condition ( $r_s = .41, p < .05$ ), which means that as the total number of digits increased, the score on the verb production ability-scale increased. The positive association between the score on the ability-scale and digit span forward approached significance ( $r_s = .36, p < .10$ ). No other associations with the score on the ability-scale and cognitive measures were found.

In the healthy control group no correlations were found between the score on the ability-scale and the cognitive measures.

Table 5 lists the Spearman coefficients of the correlations between the ability-scale and relevant clinical features of the PD patients.

No significant correlation was found between the LEDD-score (or any other clinical feature) of the PD patients and their verb production score. However, there was a trend to a relation for the average *Hoehn and Yahr* (1967) staging ( $r_s = -.36, p < .10$ ) and for the UPDRS motor score, part III ( $r_s = -.39, p < .10$ ).

#### 4. Discussion

The aim of the study was to determine whether verb production in sentence context was impaired in a group of Dutch speaking PD patients. More importantly, we wanted to verify whether this impairment was due to a linguistic deficit per se, or whether the deficit was the consequence of another

**Table 5 – Correlations between the scores on the ability-scale and the clinical features of the PD patients ( $n = 28$ ).**

		PD $r_s$ (p)
LEDD		.02 (.918)
UPDRS part III		-.39 (.054)
Hypokinesia	Right side	.03 (.89)
	Left side	-.25 (.235)
Average Hoehn & Yahr staging		-.36 (.068)
$r_s$ , Spearman's coefficient.		

cognitive deficit. In addition, the influence of relevant clinical features on verb production was also evaluated.

Mokken-scale-analysis (Mokken, 1971) was applied to develop a verb production ability-scale that ordered the items of the verb production task in terms of increasing difficulty. No empirical evidence was found for a difference in the order of difficulty of the items in the scale between PD patients and healthy controls. The verb production ability-scale was thus valid for both groups. Moreover, PD patients performed worse than the healthy controls on this scale.

The Discussion section is further organized as follows: first findings on the influence of linguistic variables on verb production in PD are presented. This is followed by a discussion on the role of executive functions and also clinical features in PD patients' verb production. The final part of the discussion aims at drawing conclusions from the presented results.

##### 4.1. Influence of linguistic variables on verb production in PD

The manipulated linguistic variables had an effect on the verb production scores of PD patients. Moreover, the pattern of errors of PD patients contrasted in a number of ways to the previous research on Broca's aphasia.

Firstly in this regard, the Dutch speaking PD patients in this study showed more difficulties with the finite verbs in base position than in derived position. The cause of the decreased performance in base position is not syntactic complexity, since few errors occurred in main clauses. Most errors occurred in subordinate clauses, which are linguistically less complex regarding the verb (i.e., no verb movement) but are longer than the main clauses. Thus, it may not be linguistic complexity but length that is the crucial factor in PD.

Secondly, PD patients in this study performed more impaired on present tense than past tense. Specifically their poor performance in the present tense sentences was due to the excessive, inappropriate use of the past tense when a present tense was required. As will be discussed in more detail in the section on the *role of executive functions in PD patients' verb production*, it is suggested that PD patients showed perseverations in the past tense framework, while task demands aimed them to switch to the present tense framework. Longworth et al. (2005) previously studied a group of patients with moderate PD and found a tendency to repeat cues instead of producing a past tense form as requested, for both regular and irregular verbs. These perseverations, along with the other errors made by PD patients were not compatible with the challenged Declarative-Procedural Model. Longworth et al.

**Table 4 – Associations between the scores on the ability-scale and cognitive measures of PD patients ( $n = 28$ ) and healthy controls ( $n = 28$ ).**

	PD $r_s$ (p)	HC $r_s$ (p)
Sustained visual attention	-.21 (.305)	.16 (.434)
Sustained auditory attention	-.21 (.298)	.11 (.599)
Divided attention	-.21 (.313)	-.23 (.271)
Digit span forward	.36 (.059)	.2 (.298)
Digit span backward	.41 (.029)*	-.08 (.688)
Set-switching (TMT A&B; OMO test)	-.61 (.001)**	-.06 (.78)
Stroop test	-.16 (.432)	.18 (.357)
Average letter fluency	.152 (.448)	.076 (.699)
Average semantic fluency	.205 (.295)	.046 (.816)
Action fluency	.140 (.485)	.221 (.259)
Sequencing simple	.04 (.83)	.12 (.546)
Sequencing complex	.26 (.186)	.22 (.273)

HC = healthy control;  $r_s$ , Spearman's coefficient; \* $p < .05$ ; \*\* $p \leq .001$ .

(2005) concluded that the striatum has a more restricted, non-language-specific inhibitory role in the selection of the appropriate representation among competing alternatives in the late integration processes of language processing. In our opinion, the observed ‘stuck-in-set perseverations’ (see perseveration taxonomy of Sandson and Albert, 1984) in the current study may have been elicited by the nature of the used materials and the associated instructions.

Thirdly, PD patients in this study made more errors in the production of intransitive verbs compared to the transitive verbs. Previously, Hochstadt et al. (2006) attributed the better comprehension of Subject–Object–Verb structures compared to center embedded structures to the higher frequency of the former in the language under study. A spontaneous speech analysis of eight healthy speakers of Dutch, revealed a frequency pattern of proportionally more transitive verbs [mean score = .67 (SD = .05)] than intransitive verbs [mean score = .24 (SD = .06)] (Bastiaanse and Jonkers, 1998). The higher frequency of transitive verbs in Dutch daily language use, might explain the better performance of PD patients for this verb category. In addition to this lexical frequency effect, we also suggest that the dissociation in the difficulty to select a verb from semantic memory might be caused by the syntactic properties of the presented sentence. The transitive constructions always contained two NPs as complements of the missing verb and the intransitive constructions always contained a subject noun phrase (NP) and a prepositional phrase (PP) as adjunct. Selecting a semantically plausible verb during the processing (i.e., reading the sentence analyzing the accompanying picture and combining these sources of information) of a transitive incomplete construction like in (1) might demand less cognitive resources than processing an intransitive incomplete construction like in (2).

(1) *The man ...{the woman}<sub>NP</sub> (expected response: kisses)*

(2) *The man ...{in the river}<sub>PP</sub> (expected response: fishes)*

Fourthly, and finally, no influence of regularity on verb production in sentence context was detected in PD patients. This result is contrary to the findings of Ullman et al. (1997), but consistent with the findings of for example Longworth et al. (2005) for the past participle in English. Our data indicate that a deficit with regular inflection is not a characteristic for Dutch speaking PD patients.

#### 4.2. Role of executive functions in PD patients' verb production

Analyses of PD patients' neuropsychological performance revealed that they showed set-switching deficits and decreased sustained visual attention. These findings are in line with a number of studies that showed attentional- and set-switching deficits in PD (e.g., Owen et al., 1993; Van Spaendonck et al., 1995). A trend toward a difference between the non-demented PD patients and the matched HCs was found for the action fluency task.

Concerning the latter finding, it is important to mention that PD patients did not differ significantly from the HCs for the semantic and letter fluency task. And although action fluency was not the most difficult task for both groups, finding

a trend toward a difference between the groups for action fluency suggests that the fronto-striatal dysfunction in PD affects especially verb generation. This is partially in line with the findings of Piatt et al. (1999a, 1999b) who suggested to use action fluency as a clinical test to differentiate PD patients with and without dementia.

In contrast to previous reports the PD patients in this study did not show evidence of reduced working memory capacity, (e.g., Caplan and Waters, 1999; Gilbert et al., 2005).

In order to answer the main question of this study, whether a verb production deficit in sentence context in PD patients was due to a linguistic deficit per se, or whether this was the consequence of another cognitive deficit, the assessed executive functions were correlated to the verb production of PD patients. And indeed, several aspects of the data are compatible with the hypothesis that executive dysfunctions were responsible for the performance of PD patients on the verb production task.

As described above, PD patients did not show a decreased working memory capacity compared to healthy controls, however verb production was associated with working memory in PD patients. This suggests that PD patients who performed worse on the verb production task showed a lower working memory capacity. In healthy controls, the production of verbs can be seen as a rather automatic language processing task, which is confirmed by the fact that no association was found between verb production and working memory in healthy controls. Automatic behavior is thought to be mediated by the basal ganglia (Saling and Phillips, 2007). Since, PD is characterized by a dopaminergic dysfunction of the basal ganglia, one can assume that PD patients cannot produce verbs in a rather automatic manner as healthy control subjects do and therefore need to rely more on their working memory. This can be interpreted as a compensatory mechanism. The difference in working memory demands of the different sentence types may be responsible for the found error pattern. Due to the length of the subordinate sentences PD patient with a relative small working memory capacity showed a working memory overload and produced errors on the verb production task. Compensatory mechanisms in PD acting toward maintenance of performance (despite the underlying degenerative process) have recently also been proposed by Marié et al. (2007). Based on their fMRI study, Marié et al. (2007) concluded that PD patients have a time-limited working memory capacity. In the context of the present study, this implies that working memory capacity might be sufficient for performing the digit span, but not for a task such as production of verbs in sentence context. Thus, despite the time-limited capacity of working memory, PD patients relied more on their working memory for verb production compared to healthy controls.

The performance on verb production of PD patients was also associated with set-switching, suggesting that PD patients who show a set-switching deficit have more difficulties with verb production. Switching deficits are a well-documented deficit both in patients with PD and prefrontal cortex lesions (Gotham et al., 1988; Cools et al., 2001). Many tense errors were made in sentences targeting the present tense. In our verb production task participants were instructed to inflect the verb in the past tense only in the presence of a past tense adverb (i.e., when receiving an external cue) and in the present tense if the

adverbial time phrase was absent (i.e., when a cue was absent and an internal response needed to be produced). It is therefore suggested that the test materials and associated instructions provoked the tense errors. Due to the absence of a tense adverb PD patients were unable to switch and showed ‘stuck-in-set perseverations’ which were evoked by the previous sentence. Consequently, they showed more problems monitoring their performance and detecting and correcting errors in their output when an external cue was absent. These results are consistent with Brown and Marsden (1988), who previously reported that PD is associated with a deficit in internal action control in the presence of preserved external control. In our study, the production of present tense with an adverbial time phrase referring to the past resulted in an ungrammatical sentence and thus an obvious extra error signal. The sentences of the present tense condition, however, contained no cue and the instruction to produce the verb in the present tense in absence of an adverbial time phrase needed to be kept in mind by the participants during the entire task. The inappropriate production of a simple past in the absence of an adverb of time did not lead to an ungrammatical sentence and only violated the instruction to be memorized. While monitoring their performance, PD patients seemed to forget this instruction, especially in the longer subordinate sentences where working memory is challenged more than in the short main clauses. Set-switching impairments appeared to play a major role in performing the task assessing verb production in sentence context and it is suggested to reduce PD patients’ performance seriously.

Cognitive sequencing, assessed with a protocol based on Lelekov et al. (2000), was not associated with verb production. Lelekov et al. (2000) claimed that their task required the manipulation of syntax-like rules and therefore correlated with a syntactic comprehension measure. The complex abstract sequence processing task of Lelekov et al. (2000) involved more working memory (allowing for temporary storage and simultaneous manipulation of the information) besides sustained visual attention. Therefore PD patients performed probably worse on the complex task than on the simple abstract sequence processing task. However, it remains unclear why a correlation between the verb ability-scale and either of the two sequencing tasks was absent. As an alternative explanation we consider that the verb production task did not rely as much on cognitive sequencing as the sentence comprehension task used by Lelekov et al. (2000), as the subjects are instructed to fill in a verb after reading the sentence.

#### 4.3. Influence of clinical features on PD patients’ verb production

PD is responsible for the verb production deficits in a group of early stage PD patients, as suggested by the trends to an association between the clinically evaluated level of motor dysfunction (UPDRS part III and average Hoehn and Yahr, 1967) and verb production. These trends in association indicate that verb production became more problematic with progression of PD. Finally, no associations were found between the performance on the verb production task and the use of dopaminergic therapy. This indicates that levodopa use does not influence verb production in PD patients. However, previous studies do suggest that levodopa use has an

influence on cognition in PD patients (Cools, 2006; Lange et al., 1992). Lange et al. (1992) concluded that, levodopa withdrawal can selectively impair performance on executive functions tests, without affecting the performance on tests of visual memory and learning. Verb production in this study may have been indirectly (positive or negative) influenced by the dopaminergic therapy. Future research should therefore clarify whether PD patients off their medication still have the same verb production impairment as medicated PD patients. Also, follow up with on-line tasks is necessary and should minimize the influence of working memory and set-switching to assess purely verb production in PD patients.

## 5. Conclusions

In conclusion, verb production deficits in PD differ from those usually observed in agrammatic stroke patients. It is suggested that due to a failing automaticity of verb production, PD patients need to rely more on the cortical represented executive functions, which, unfortunately, are also dysfunctional. The findings of this study evidenced that a working memory overload and set-switching impairments can lead to verb production deficits in PD. This is in line with conclusions for receptive language impairments in PD. Our data put forward working memory and set-switching impairments as key factors of the verb production deficits in PD. Without doubt executive functions must thus be seen as a necessary part of the language network.

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## Appendix A

**Table A1 – The infinitives of the 20 verbs used in the verb production task.**

Regular verb	Transitivity	Irregular verb	Transitivity
Bedelen (to beg)	I	Bijten (to bite)	T
Filmen (to film)	T	Blazen (to blow)	I
Geeuwen (to yawn)	I	Dragen (to carry)	T
Knielen (to kneel)	I	Duiken (to dive)	I
Koken (to cook)	T	Hangen (to hang)	I
Kussen (to kiss)	T	Lezen (to read)	T
Schermen (to fence)	I	Spuiten (to hose)	T
Vissen (to fish)	I	Varen (to sail)	I
Wurgen (to strangle)	T	Wringen (to wring)	T
Zeven (to sift)	T	Zitten (to sit)	I
English translation between brackets. T = Transitive verb, I = Intransitive verb.			

## Appendix B

**Table B1 – The 45 items of the verb production ability-scale, ranging from the most difficult to the easiest item. To clarify the position of the verb, the target verbs are underlined.**

Scale number	Item in sentence context	English translation	Mean % correct in population
1	Dit is het kind dat in de soep <u>blaast</u>	This is the child who blows (in) the soup	77
2	Dit is de jongen die in een boek <u>leest</u>	This is the boy who reads a book	82
3	Dit is het meisje data aan de ringen <u>hangt</u>	This is the girl who hangs on the rings	82
4	Dit is de vrouw die in het zwembad <u>duikt</u>	This is the woman who dives into the swimming pool	82
5	Dit is de man die in de kerk <u>knielt</u>	This is the man who kneels in the church	84
6	Dit is de vrouw die de man <u>filmt</u>	This is the woman who films the man	84
7	Dit is de hond die de kat <u>bijt</u>	This is the dog that bites the cat	86
8	Dit is de man die op een bankje <u>zit</u>	This is the man who sits on a bench	86
9	Dit is de man die het bloemperk <u>sput</u>	This is the man who waters the flowers	88
10	Dit is de man die vrouw <u>kust</u>	This is the man who kisses the woman	89
11	Dit is de man die op de straathoek <u>bedelt</u>	This is the man who begs at the street corner	89
12	De man <u>knielt</u> in de kerk	The man kneels in the church	91
13	Dit is de man die de vrouw <u>wurgt</u>	This is the man who strangles the woman	91
14	Dit is de vrouw die de dweil <u>wringt</u>	This is the woman who wrings the floor cloth	91
15	De vrouw <u>zeeft</u> het meel	The woman sifts the flower	91
16	De man <u>vaart</u> in de boot	The man goes boating	93
17	Dit is de man die in de rivier <u>vist</u>	This is the man who fishes in the river	93
18	De jongen <u>geeuwt</u> in zijn pyjama	The boy yawns in his pyjamas	93
19	Dit is het kind dat daarnet in de soep <u>blies</u>	This is the child who just blew in the soup	93
20	Het meisje <u>hangt</u> aan de ringen	The girl hangs on the rings	95
21	Dit is de man die gisteren in de kerk <u>knielde</u>	This is the man who kneeled in the church yesterday	95

**Table B1 (continued)**

Scale number	Item in sentence context	English translation	Mean % correct in population
22	Dit is de kok die de soep <u>kookt</u>	This is the cook who cooks the soup	95
23	Dit is de man die in de boot <u>vaart</u>	This is the man who goes boating	95
24	De vrouw <u>dook</u> vorige week in het zwembad	The woman dove into the swimming pool last week	95
25	De man <u>vist</u> in de rivier	The man fishes in the river	95
26	De man <u>kust</u> de vrouw	The man kisses the woman	96
27	De vrouw <u>filmt</u> de man	The woman films the man	96
28	De man <u>zit</u> op een bankje	The man sits on a bench	96
29	De man <u>sput</u> het bloemperk	The man waters the flowers	96
30	Dit is de vrouw die gisteren de man <u>filmde</u>	This is the woman who filmed the man yesterday	96
31	De jongen <u>leest</u> een boek	The boy reads a book	96
32	De man is de vrouw aan het <u>wurgen</u>	The man is strangling the woman	96
33	Dit is de man die vorig jaar op de straathoek <u>bedelde</u>	This is the man who begged at the street corner last year	96
34	De man is het bloemperk aan het <u>sputen</u>	The man is watering the flowers	96
35	De kok <u>kookt</u> de soep	The cook cooks the soup	96
36	Dit is de kok die een uur geleden de soep <u>kookte</u>	This is the cook who cooked the soup an hour ago	96
37	De jongen <u>las</u> gisteren een boek	The boy read a book yesterday	98
38	De hond <u>bijt</u> de kat	The dog bites the cat	98
39	De man <u>viste</u> vorige week in de rivier	The man fished in the river last week	98
40	De man <u>wurgt</u> de vrouw	The man strangles the woman	98
41	De hond <u>beet</u> vorige week de kat	The dog bit the cat last week	98
42	Dit is de jongen die gisteren een boek <u>las</u>	This is the boy who read a book yesterday	98
43	De man is in de boot aan het <u>varen</u>	The man is boating	98
44	Het meisje <u>draagt</u> de jongen	The girl carries the boy	98
45	De man is de vrouw aan het <u>kussen</u>	The man is kissing the woman	98



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